OPERATION BOOK

for

MODEL FM-9CG

•

FREQUENCY METER

•

DEVIATION METER

•

SIGNAL GENERATOR

THE SINGER COMPANY
METRICS DIVISION

3211 S. LA CIENEGA BLVD., LOS ANGELES, CALIFORNIA
TELEPHONE (213) 870-2741 • TWX 213-836-0466

Design and production of PANORAMIC • SENSITIVE RESEARCH
• EMPIRE • GERTSCH instruments for measurement

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Gertsch
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454 TO 460 MHZ CHANNEL FREQUENCIES

Channel Frequency	Dial Setting	Channel Frequency	Dial Setting
454	151.33333	455.5	151.83333
454.025	151.34167	455.525	151.84167
454.05	151.35	455.55	151.85
454.075	151.35833	455.575	151.85833
454.1	151.36667	455.6	151.86667
454.125	151.375	455.625	151.875
454.15	151.38333	455.65	151.88333
454.175	151.39167	455.675	151.89167
454.2	151.4	455.7	151.9
454.225	151.40833	455.725	151.90833
454.25	151.41667	455.75	151.91667
454.275	151.425	455.775	151.925
454.3	151.43333	455.8	151.93333
454.325	151.44167	455.825	151.94167
454.35	151.45	455.85	151.95
454.375	151.45833	455.875	151.95833
454.4	151.46667	455.9	151.96667
454.425	151.475	455.925	151.975
454.45	151.48333	455.95	151.98333
454.475	151.49167	455.975	151.99167
454.5	151.5	456.	152.
454.525	151.50833	456.025	152.00833
454.55	151.51667	456.05	152.01667
454.575	151.525	456.075	152.025
454.6	151.53333	456.1	152.03333
454.625	151.54167	456.125	152.04167
454.65	151.55	456.15	152.05
454.675	151.55833	456.175	152.05833
454.7	151.56667	456.2	152.06667
454.725	151.575	456.225	152.075
454.75	151.58333	456.25	152.08333
454.775	151.59167	456.275	152.09167
454.8	151.6	456.3	152.1
454.825	151.60833	456.325	152.10833
454.85	151.61667	456.35	152.11667
454.875	151.625	456.375	152.125
454.9	151.63333	456.4	152.13333
454.925	151.64167	456.425	152.14167
454.95	151.65	456.45	152.15
454.975	151.65833	456.475	152.15833
455.	151.66667	456.5	152.16667
455.025	151.675	456.525	152.175
455.05	151.68333	456.55	152.18333
455.075	151.69167	456.575	152.19167
455.1	151.7	456.6	152.2
455.125	151.70833	456.625	152.20833
455.15	151.71667	456.65	152.21667
455.175	151.725	456.675	152.225
455.2	151.73333	456.7	152.23333
455.225	151.74167	456.725	152.24167
455.25	151.75	456.75	152.25
455.275	151.75833	456.775	152.25833
455.3	151.76667	456.8	152.26667
455.325	151.775	456.825	152.275
455.35	151.78333	456.85	152.28333
455.375	151.79167	456.875	152.29167
455.4	151.8	456.9	152.3
455.425	151.80833	456.925	152.30833
455.45	151.81667	456.95	152.31667
455.475	151.825	456.975	152.325

454 TO 460 MHZ CHANNEL FREQUENCIES

Channel Frequency	Dial Setting	Channel Frequency	Dial Setting
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457.8	152.6	459.3	153.1
457.825	152.60833	459.325	153.10833
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458.475	152.825	459.975	153.325
		460.	153.33333

BRIEF OPERATING INSTRUCTIONS

TRANSMITTER FREQUENCY CHECK

CAUTION: Do not key transmitter when directly coupled to the FM-9. Excessive input signal will damage the instrument.

1. With unit plugged into a suitable power source, allow a 30 minute warmup to stabilize crystal oven.

2. Extend internal telescoping antenna.

3. Turn RF OUTPUT switch to ANT. position.

4. Turn FUNCTION switch to CAL position.

5. Set MHZ, 100 KHZ, & 0-100 KHZ dials to channel frequency.

NOTE: Fundamental band channels are direct reading. Harmonic band channels must be divided by 3.

6. Set 0-100 KHZ dial to nearest 5 KHZ cal point (yellow calibration marks).

NOTE: Fundamental band channels are on calibration marks.

7. Adjust CAL knob for zero beat, using speaker and beat meter.

8. Turn FUNCTION switch to MEAS. GEN. position.

9. Re-set 0-100 KHZ dial to harmonic channel divided by 3. Ignore this step for fundamental band.

10. Key transmitter. The tone heard in the speaker is the difference between the transmitter frequency and the channel frequency. The antenna length may be adjusted for optimum coupling.

11. The transmitter may now be set by adjusting its frequency for a zero beat against the FM-9 setting, or its frequency determined by adjusting FM-9 0-100 KHZ control for zero beat. The FM-9 0-100 KHZ dial has three 200 cycle markers on each side of the channel for this purpose.

TRANSMITTER DEVIATION CHECK

1. After the transmitter frequency has been set, change FM-9 dial readings (either up or down) by 300 KHZ.

NOTE: A change of only 100 KHZ is required for harmonic channels since the 3rd harmonic is being used.

2. Turn FUNCTION switch to LIM. CUR. position.

3. Key transmitter for limiter current reading. Meter reading must be above red line. If not, increase coupling and re-check frequency.

4. Turn FUNCTION switch to FREQ. SET position. Meter needle should be on red line. If not, adjust FM-9 0-100 KHZ dial for red line reading.

5. Turn FUNCTION switch to 5 KHZ or 15 KHZ position. Noise will cause a residual deviation when the transmitter is not keyed.

6. Key transmitter and modulate by speaking into microphone. Peak deviation is read directly on meter.

NOTE: The deviation on either side of channel frequency may be read by using DEVIATION + - switch. The demodulated audio is present in the speaker or phone output.

RECEIVER CHECKOUT

1. Connect FM-9 INPUT/OUTPUT jack to receiver antenna connector.

CAUTION: Do not key transmitter while directly connected to FM-9.

2. Repeat steps 4 through 9 of "Transmitter Frequency Check".

3. Adjust RF OUTPUT control to desired output level.

4. Discriminator center of receiver may now be set and sensitivity checked. The FM-9 output may be adjusted to as low as 0.5 uv.

5. The output of the FM-9 may be frequency modulated by applying a 0 to 1 vrms tone to the EXT MOD connector. A 1 vrms tone will cause 5 KHZ deviation in the fundamental or 15 KHZ deviation in the harmonic band.

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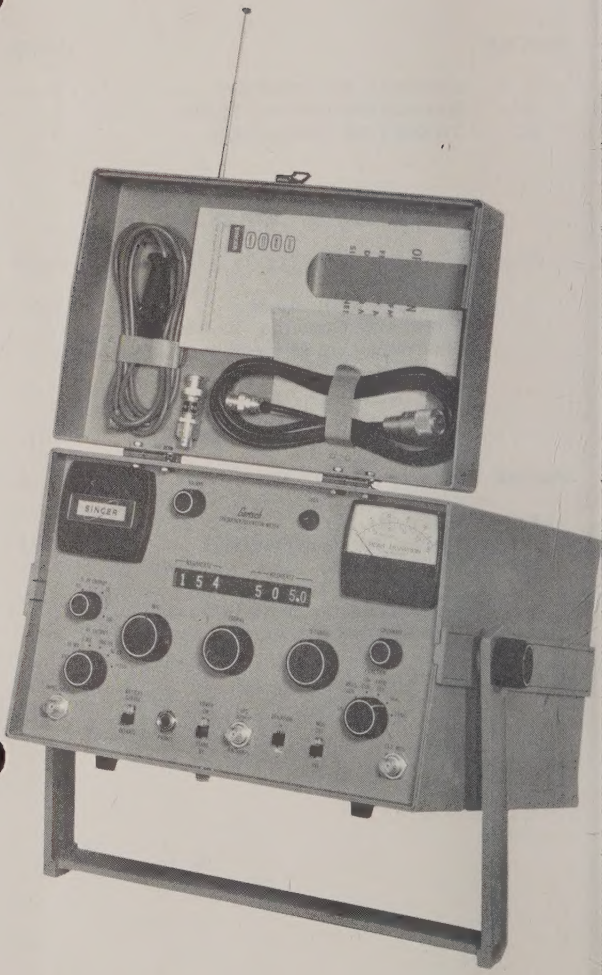


Figure 1-1. Model FM-9CG

SECTION I
GENERAL DESCRIPTION

1-1. PURPOSE.

1-2. The Model FM-9CG performs quick, accurate tests of communications transmitters and receivers operating in the 152 to 164 MHZ range. By using the third harmonic of the settings, the instrument may also be used to test equipment operating in the 456 to 492 MHZ range.

1-3. To test transmitters, the instrument functions as a frequency meter and deviation meter. Sensitivity is such that in many cases transmitters operating within a communications area can be checked from one central location. The built-in antenna should provide sufficient coupling for most applications. Simplified measurement techniques make it possible to check transmitters during normal working transmissions.

1-4. Only one zero beat is required to set a transmitter to channel frequency. Beat notes are presented aurally and visually: aurally by a built-in audio amplifier and speaker, and visually by a front panel meter (to less than 5 HZ). A front panel volume control and head phone jack are included. Variations from channel frequency can be measured using a beat note and dial interpolation method (the dials include 200 HZ markings for this purpose).

1-5. As a deviation meter, peak deviations of the frequency modulation can be measured using a 0 to 5 KHZ or a 0 to 15 KHZ range. Upper and lower sidebands are checked separately and may be compared by operating a front panel switch.

1-6. The audio output of a transmitter may be checked aurally or visually. The aural check is obtained through a combination of the deviation meter circuitry and the audio system. The visual check is obtained by connecting a scope to a set of rear-panel jacks. The jacks are connected directly to the output of the deviation meter discriminator.

1-7. To check receivers, the instrument functions as a signal generator. A six foot coax cable, equipped with BNC to UHF connectors, is supplied with the unit for direct coupling a receiver. For quick checks of receiver frequency, the signal can be transmitted with the antenna.

1-8. Coarse and fine controls provide continuous antenuation of the output signal from 50 mv to 0.5 uv. Frequency modulation can be applied to the output signal. A continuously variable 400 to 500 KHZ signal is available at a front panel connector for use in aligning the IF portion of receivers.

1-9. FREQUENCY COVERAGE AND ACCURACY.

1-10. The instrument has a guaranteed accuracy of ±0.0001% (± one part per million) when used to measure or generate any of the channel frequencies within its range. Frequency is set by adjusting three dials to a channel frequency and is continuously variable throughout the range. Every 5 KHZ channel frequency is a self-calibration point, eliminating any need for charts, graphs, or calibration books.

1-11. At the 5 KHZ points, accuracy is determined by a single internal 1 mc crystal, mounted in a temperature control oven. The crystal may be checked against the adjusted to an external standard or standards frequency broadcase (such as WWV) without removing the case.

1-12. PORTABILITY.

1-13. All components are housed in a single sturdy case, equipped with a carrying handle. Solid state circuits are used through out to reduce size, weight, and power consumption. Basic accuracy is maintained over the temperature range at 32° to 120°F (0° to 50°C). The case is designed to operate in a horizontal or vertical position and operating position does not affect accuracy.

1-14. Standard 115 vac, 50 to 400 HZ power or a 12 vdc source such as a car battery may be used to operate the instrument, or maintain temperature in the crystal oven. Conversion from ac to dc power is accomplished by operating a switch. A cable, equipped with a cigarette lighter connector, is supplied to simplify connections to a car or truck battery.

1-15. For portable use, a 13.5 volt alkaline battery is recommended. The ac to dc power supply of the instrument can be converted to a battery charger circuit by operating a switch. The battery charger may be used for automatically controlled, over-night recharging.

TABLE 1. GENERAL SPECIFICATIONS

FREQUENCY	
RANGE	
Fundamental	152 - 164 MHZ
Harmonics	456 - 492 MHZ
ACCURACY	± 0.0001% (± 1 ppm) (After 30 minutes warmup)

TABLE 1. GENERAL SPECIFICATIONS (continued)

DEVIATION MEASUREMENTS

RANGE
Low . . . . . 0 to 5 KHZ
High . . . . . 0 to 15 KHZ

ACCURACY . . . . . ± 5% of full scale

SENSITIVITY, FREQUENCY AND DEVIATION MEASUREMENTS

Fundamental . . . . . 1 mv
Harmonic . . . . . 5 mv

RF OUTPUT

RANGE
Fundamental . . . . . 50 mv to 0.5 uv

ACCURACY (Calibrated into 50 ohm load)
0.5 uv . . . . . ± 2 db (with RFA-20)
All other points . . . . . ± 4 db

ZERO BEAT INDICATORS

Aural . . . . . Built-in audio amplifier and speaker

Visual . . . . . Meter

INTERNAL FREQUENCY MODULATION

Fundamental . . . . . 5 KHZ at 1000 HZ

EXTERNAL FREQUENCY MODULATION

Fundamental
300 to 3,000 HZ . . . . . 5 KHZ deviation
100 HZ . . . . . 2 KHZ minimum

Harmonic
300 to 3,000 HZ . . . . . 15 KHZ deviation
100 HZ . . . . . 6 KHZ minimum

Required Audio Input . . . . . 1 vrms (approx)

AUXILIARY OUTPUTS

IF ALIGNMENT SIGNAL
Frequency . . . . . 400 - 500 HZ, with high harmonic content
Amplitude . . . . . 3 v peak to peak
Source Impedance . . . . . 1 k

TABLE 1. GENERAL SPECIFICATIONS (continued)

CRYSTAL CALIBRATION SIGNAL	1 MHZ pulse
POWER REQUIREMENTS	
AC	115/230V, 500 to 400 HZ, 7 va
DC	11.5 to 15 v, approximate 0.3 amp average current, NEGATIVE ground
OPERATING TEMPERATURE RANGE	32° to 120°F (0° to 50°C)
FURNISHED ACCESSORY EQUIPMENT	Built-in battery charger and voltmeter Six foot coax cable, 50 ohms, BNC to UHF connectors DC power cable, cigarette lighter connector RFA-20, 20 db attenuator for accurate control of output in the 5 uv range.

SECTION II
OPERATING INSTRUCTIONS

2-1. GENERAL.

2-2. Refer to Table 2 for the function of the various controls, indicators, and connectors. This section includes a warm-up procedure (paragraph 2-4), a battery charge procedure (paragraph 2-6), an expanded transmitter checkout procedure (paragraph 2-8 through 2-12), a receiver checkout procedure (paragraph 2-14 through 2-16), and notes on operation (paragraph 2-18 and subsequent).

2-3. WARM-UP.

2-4. A maximum of 30 minutes is required to warm-up the instrument from a cold start. To start the instrument, proceed as follows:

a. To use an 11 to 15 vdc source:

1. Slide DC/AC switch (located on rear panel) to DC position.

CAUTION

Make certain that the external source provides a negative ground.

2. Slide BATTERY CHARGE/OPERATE switch to the OPERATE position.

3. Connect power to the 11-15 vdc jack. To connect to a car or truck battery through the cigarette lighter, use the special cable furnished with the equipment.

4. For warm-up, leave POWER switch in STANDBY. To operate equipment, turn switch to ON.

5. To check voltage (or battery charge) of an external source, slide BATTERY CHARGE switch to the CHARGE position. Use the 0 to 15 scale of the meter to read voltage. When voltage check is complete, slide switch to the normal position.

b. To use a 115 vac source:

1. Slide DC/AC switch to the AC position.

2. Slide 115/230 switch to the 115 position.

3. Make certain that a 1/4 amp fuse is installed in AC fuseholder.

4. Connect power cable to a 115 vac outlet.

5. For warm-up, leave POWER switch in STANDBY. To operate equipment, turn switch to ON.

TABLE 2. FUNCTION OF OPERATING CONTROLS, INDICATORS, AND CONNECTORS

PANEL MARKING	TYPE OF CONTROL	FUNCTION
	Speaker	For detection of beat notes and monitoring audio output of transmitters
VOLUME	Potentiometer	Adjust output of audio system
OVEN	Indicator light	Lights to indicate that the heater of the crystal oven is supplied with power
	Meter	With the BATTERY switch in the CHARGE position, indicates voltage level of external dc supply. (0 to 15 vdc scale)
		With FUNCTION switch in the MEAS GEN or CAL position, indicates beat notes
		With FUNCTION switch in the LIM CUR position, checks incoming signal level
		With FUNCTION switch in the FREQ SET position, checks IF frequency to the discriminator circuit
		With FUNCTION switch in the 5 KHZ or 15 KHZ position, indicates peak deviations of transmitter modulation

TABLE 2. FUNCTION OF OPERATING CONTROLS, INDICATORS, AND CONNECTORS (cont)

PANEL MARKING	TYPE OF CONTROL	FUNCTION
% RF OUTPUT	Potentiometer	Fine attenuator control of output signal
RF OUTPUT	Six position rotary switch	Coarse attenuator control of output signal. The built-in antenna is connected into the system with the switch in ANT. position and connected to ground in the remaining positions
MKZ	12 position rotary switch	Sets megacycle portion of frequency
100 KHZ	10 position rotary switch	Sets 100 KHZ portion of frequency
0-100 KHZ	Variable capacitor	Sets 0 to 100 KHZ portion of frequency
INPUT/OUTPUT	BNC connector	Means for directly coupling signals into or out of the instrument. The antenna couples transmitted or received signals
LFO CALIBRATE	Variable capacitor	Calibrates 0-100 KHZ readout against the self-contained crystal
PHONES	Jack	Connection point for a 100 ohm headset. The self-contained speaker is disconnected from the audio system when a connection is made

TABLE 2. FUNCTION OF OPERATING CONTROLS, INDICATORS, AND CONNECTORS (cont)

PANEL MARKING	TYPE OF CONTROL	FUNCTION
POWER ON/ STANDBY	Slide switch	Power switch. In the STANDBY position, power is supplied to the oven heater circuit.
LFO OUTPUT	BNC connector	Supplies continuously variable 400 to 500 KHZ output for alignment of receiver IF stages
DEVIATION	Slide switch	Allows measurements of the upper (+) and lower (-) sidebands. This switch is also called a symmetry or polarity switch in some test procedures.
MOD EXT/INT	Slide switch	Selects either an internal 1 KHZ FM modulation or an external source. This switch must be in the EXT position during frequency checks.
EXT MOD	BNC connector	Applies FM modulation to the RF output from external audio source
FUNCTION	6 position rotary switch	In the CAL position, switches circuitry so that the 5 KHZ points of the dial may be checked against the crystal
		In the MEAS GEN position, switches circuitry for standard frequency meter or signal generator operation
		In the LIM CUR position, switches circuitry to check the level of the incoming signal. A minimum signal level is required for accurate deviation meter measurements.

TABLE 2. FUNCTION OF OPERATING CONTROLS, INDICATORS. AND CONNECTORS (cont)

PANEL MARKING	TYPE OF CONTROL	FUNCTION
FUNCTION (cont)		In the FREQ SET position, switches circuitry to check the IF frequency to the discriminator circuit. An exact center frequency is required for accurate deviation meter measurements.
		In the 5 KHZ position, switches circuitry to measure peak deviations in the 0 to 5 KHZ range
		In the 15 KHZ position, switches circuitry to measure peak deviation in the 0 to 15 KHZ range
DISCR OUTPUT	Jacks (two)	Permits checks of peak deviation with an oscilloscope. The jacks are connected directly to the output of the discriminator circuit.
11 - 15 VDC	Jack	Connection point for a VDC power source
VDC	Fuse	Protection for DC power input and for unregulated DC output of the internal power supply
AC	Fuse	Protection for AC power input
DC/AC	Slide switch	Switches input circuit to accommodate AC or DC input power

TABLE 2. FUNCTION OF OPERATING CONTROLS, INDICATORS, AND CONNECTORS (cont)

PANEL MARKING	TYPE OF CONTROL	FUNCTION
DC/AC (cont)	Power cable	Connection point for a VAC power source
BATTERY CHARGE/ OPERATE	Slide switch	Converts AC power supply to a DC charger circuit, and switches meter circuitry to measure voltage level of external DC source
1 MHZ OUTPUT	BNC connector	Provides 1 mc pulses for checking the crystal against an external standard
MHZ ADJ	Variable capacitor	Permits adjustment of crystal output frequency to an external standard
115/230	Slide switch	Switches input circuit to accommodate 115 vac or 230 vac power
LOCKED/ NORMAL	Slide switch	In the NORMAL position, the LFO is free running. In the LOCKED position, the LFO is locked to the crystal through a harmonic of the 5 KHZ divider.
FREQ CONV	Special connector	Connection point for a frequency converter, Model FC-3 or FC-4

c. To use a 230 vac source:

1. Slide DC/AC switch to the AC position.

2. Slide 115/230 switch to the 230 position.

3. Install a 1/8 amp fuse in the AC fuseholder.

4. Connect power cable to a 230 vac outlet.

5. For warm-up, leave POWER switch in STANDBY. To operate equipment, turn switch to ON.

d. When power is first applied, the OVEN lamp should light. When the crystal is warmed up to operating temperature, the lamp will begin to cycle on and off.

2-5. BATTERY CHARGE.

2-6. To recharge a battery pack, proceed as follows:

a. Connect battery pack to the 11-15 vdc jack.

b. Connect power cord to a vac outlet.

c. Slide DC/AC switch to the AC position.

d. Turn POWER switch to ON.

e. Turn BATTERY switch to CHARGE.

NOTE

With the switch in this position, the meter indicates battery voltage (0 to 15 v scale).

f. The charger circuit will charge to a maximum voltage of approximately 12.6 vdc. At 12.6 vdc, the current output will reduce to a trickle charge automatically.

NOTE

The crystal oven is turned off while the BATTERY switch is in the CHARGE position.

2-7. TRANSMITTER CHECKOUT.

2-8. COUPLING. For most transmitters or oscillators, the self-contained antenna will provide sufficient coupling for the checkout. The antenna length may be adjusted for maximum signal at a given frequency or adjusted to attenuate the incoming signal.

a. Excessive signal may damage the input circuit if the instrument is operated within a few feet of a transmitting antenna.

b. With weak signals, a simple wire extension of the antenna may provide the additional coupling needed.

c. An external antenna may be connected to the INPUT OUTPUT jack. In this case, the RF OUTPUT switch may be used to attenuate the incoming signal. The INPUT OUTPUT jack may also be used for direct coupling.

2-9. FREQUENCY CHECK. To check or set the frequency of a transmitter, proceed as follows:

a. Turn RF OUTPUT switch to the ANT. position and extend the antenna.

b. Dial in the channel frequency with the MHZ, 100 KHZ, and 0-100 KHZ controls. In the harmonic range, divide channel frequency by 3 to obtain dial frequency (See figure 2-1).

c. Turn FUNCTION switch to the CAL position.

d. Check that dials are set to a KHZ (yellow marking) calibration point. In the fundamental range, each assigned channel frequency is a calibration point. In the harmonic range, it may be necessary to reset the dials to the nearest calibration point with the 0-100 KHZ control.

e. Set MOD switch to the EXT position.

f. Adjust CALIBRATE control as required to obtain a zero beat. The meter may be used to visually check low frequency beat notes.

NOTE

The internal speaker is disconnected when a headset is plugged into the PHONES jack.

g. Turn FUNCTION switch to the MEAS GEN position and proceed with the frequency check. If necessary, reset dials to the channel frequency.

2-10. To measure difference from channel frequency, proceed as follows:

a. Key the transmitter.

b. Adjust 0-100 KHZ control as required to obtain a zero beat.

c. Read frequency difference from the last (right hand) dial of the readout. The dial includes three markings on either side of the channel frequency marking for 200 HZ increments. Always read difference from the closest channel marking.

2-11. PEAK DEVIATION. To measure peak deviation of the modulation, proceed as follows:

a. Dial in a frequency 300 KHZ above or below the channel frequency (100 KHZ above or below in the harmonic range).

NOTE

Do not use the LOCKED (LOCKED/NORMAL switch in LOCKED position) mode when measuring peak deviations. The 5 KHZ spikes used to lock the LFO will cause residual FM in the Model FM-9 output.

b. Turn FUNCTION switch to the LIM CUR position.

c. Key the transmitter and check meter reading. If meter reading is below the red line, additional coupling is required (or the frequency setting may be wrong).

d. Turn FUNCTION switch to the FREQ SET position.

e. Key the transmitter.

f. Adjust 0-100 KHZ control as required to set the meter to the FREQ SET line.

g. Turn FUNCTION switch to the 5 KHZ or 15 KHZ position.

NOTE

With the transmitter off, normal noise pickup will cause some indication on the meter.

h. Key the transmitter and apply modulation (voice or tone may be used). Peak deviation may be read directly from the meter.

i. To check linearity of the sidebands, repeat peak deviation check with the DEVIATION switch in the "+" and "-" positions.

j. To check residual FM of transmitter, key the transmitter with no modulation applied.

2-12. AUDIO CHECK. To check the audio output of the transmitter, proceed as follows:

a. To monitor audibly, key the transmitter and speak into the microphone (tones may also be used). Adjust VOLUME control to the required listening level.

b. To monitor visually, connect oscilloscope to the DISCR OUTPUT jacks. The DISCR OUTPUT jacks are connected directly to the output of a discriminator circuit.

2-13. RECEIVER CHECKOUT.

2-14. FREQUENCY CHECK. To check a receiver, proceed as follows:

a. Connect signal cable between receiver and the INPUT/OUTPUT jack.

NOTE

For a quick check of frequency, the signal may be transmitted over the built-in antenna. To use the antenna, the RF OUTPUT switch must be in the ANT. position.

b. Dial the channel frequency with the MHZ, 100 KHZ, and 0-100 KHZ controls. In the harmonic mc range, divide channel frequency by 3 to obtain dial frequency (See figure 2-1).

c. Turn FUNCTION switch to the CAL position.

d. Check that dials are set to a KHZ (yellow marking) calibration point. In the fundamental range, each assigned channel frequency is a calibration point. In the harmonic range, it may be necessary to reset the dials to the nearest calibration point with the 0-100 KHZ control.

e. Set MOD switch to the EXT position.

f. Adjust CALIBRATE control as required to obtain a zero beat.

g. Turn the FUNCTION switch to the MEAS GEN position.

h. Set output to the required level with the RF OUTPUT switch and % RF OUTPUT potentiometer.

2-15. AUDIO TESTS. To test the audio response of a receiver, proceed as follows:

a. To use the 1 KHZ source, turn MOD switch to INT. The FM-9 output will be modulated at a 1 KHZ rate and a peak deviation of 5 KHZ.

b. To use an external source, turn MOD switch to EXT and connect modulation source to the EXT MOD connector.

NOTE

When check is complete, turn MOD switch to EXT and disconnect external modulation source.

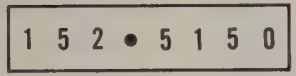
FUNDAMENTAL RANGE		HARMONIC RANGE
152.515 MHZ	DESIRED OUTPUT FREQUENCY	460.195 MHZ
152.515 MHZ	FUNDAMENTAL FREQUENCY	153.398333....
	DIAL READING	
	FREQUENCY CONTROLS	
MHZ 100 KHZ 0 - 100 KHZ		MHZ 100 KHZ 0 - 100 KHZ

Figure 2-1. Typical Frequency Settings

2-16. IF ALIGNMENT. The 400 to 500 KHZ output of the low frequency oscillator is available at the LFO OUTPUT jack. The frequency is set by the 0-100 KHZ control and is equal to 400 KHZ plus the reading of the last two dials. The remaining controls and dial settings do not affect the LFO OUTPUT frequency.

EXAMPLE: To set frequency to 455 KHZ, turn 0-100 KHZ control until next to last dial reads 5 and the last dial reads 50. 400 + 50 + 5.0 = 455 KHZ.

2-17. NOTES ON OPERATION.

2-18. The dials are marked to provide a readout of every channel frequency in the fundamental and the third harmonic range. To make certain of complete coverage, the dials are marked at each 5 KHZ point and each 1/3 point between the 5 KHZ points. At the 1/3 point, the final digit of the frequency readout is a continuously repeating number. For instance, when the dials are set to 153.3983, the fundamental output frequency is 153.3983333..MHZ. Use of the 1/3 points eliminates any need for dial interpolation in the harmonic range.

2-19. The DISCR OUTPUT jacks are not equipped with a 6 db per octave (750 microsecond) de-emphasis network. If a 750 microsecond network is required, connect a 7500 picofarad capacitor between the two jacks. (A 100K series resistor is included in the output circuit.)

2-20. The LOCKED/NORMAL switch may be used to increase accuracy at the 5 KHZ increments to the accuracy of the crystal. To increase accuracy, proceed as follows:

a. Turn switch to the LOCKED position.

b. Set the Model FM-9 to frequency.

c. Turn FUNCTION switch to CAL position.

d. Adjust LFO CALIBRATE control as required to obtain on absolute zero beat. At absolute zero, the meter will indicate zero and no beat note will be heard.

e. Proceed with checkout.

2-21. RF ATTENUATOR, MODEL RFA-20. The Model RFA-20 attenuator provides a 20 db (10 to 1 voltage) attenuation of the output signal. For accurate readout of output (±2 db) in the 5 uv range, proceed as follows:

a. Connect Model RFA-20 to INPUT/OUTPUT jack.

b. Connect receiver to Model RFA-20.

c. Set RF OUTPUT switch to the 50 uv position. (50 divided by 10 equals 5).

d. Set output to the required level with % RF OUTPUT control.

2-22. MODULATION FREQUENCY RANGE. The deviation meter circuit is designed for accurate measurements in the normal voice frequency range (100 to 3,000 HZ). If readings outside of this range are indicated, this probably indicates problems in the modulation limiting circuit of the transmitter. Although the wave shape of the audio input is not critical, the meter circuit will not respond to narrow spikes with a low repetition rate. To check transmitters for spikes, connect an oscilloscope to the DISCR OUTPUT jacks.

2-23. ACCURACY. The Model FM-9 is essentially a synthesizer with accuracy determined by the 1 MHZ crystal. For 0.0001% accuracy, the crystal must be checked against a standard or a standards frequency every 30 days. Even greater accuracy can be obtained within two hours after the crystal check. For 0.0002% accuracy; the crystal need only be checked every 90 days. Since rapid variations in temperature also affect accuracy, always allow the instrument to stabilize for at least 1 hour to a new temperature (+ 15). For greater than 0.0001% accuracy, a stable temperature of 65°F ±10°F is required.

2-24. ADDITIONAL CALIBRATION POINTS. In addition to the 5 KHZ points additional calibration points using background beat notes may be used. At the 1.667, 2.5, 3.333, 6.667, 7.5, and 8.333 points, there are loud, high frequency beat notes and quiet, low frequency beat notes. These notes are based on harmonics of the basic frequency and higher order harmonics of the 5 KHZ calibration frequency. Be carefully zeroing out the background beat notes, the unit may be calibrated at these additional points. With very careful tuning, the unit may even be locked to these points.

2-25. SETTING OR CHECKING MODULATION LEVEL. To set or check the modulation output of the FM-9, a transmitter operating at approximately the desired frequency is required. Proceed as follows:

a. Set up the Model FM-9 to measure deviation of the transmitter.

b. With no modulation applied to the transmitter, apply modulation to the FM-9.

c. Use the peak deviation meter of the FM-9 to measure the peak deviation of the FM-9 (or to set the level of an external source).

d. Set the Model FM-9 to frequency and proceed with receiver checks.

2-26. CALIBRATING AN OSCILLOSCOPE FOR PEAK DEVIATION CHECKS. To calibrate an oscilloscope, proceed as follows:

a. Connect oscilloscope to the DISCR. OUTPUT jacks. Operate the oscilloscope in the DC mode.

b. Set up the Model FM-9 to measure deviation of the transmitter.

c. With no modulation applied, the dc output of the discriminator is approximately 3 vdc. Set this voltage for center reference.

d. Offset the FM-9 frequency by 5 KHZ. This is one 5 KHZ limit.

e. Offset the FM-9 frequency by 5 KHZ in the other direction. This becomes the second 5 KHZ limit.

f. Reset the FM-9 to the center of deviation IF.

g. Modulate the transmitter. The oscilloscope reading should be within the limits established in steps d and e.

SECTION III
THEORY OF OPERATION

3-1. FREQUENCY METER OPERATION. (See figure 3-1.)

3-2. When the Model FM-9 is used as a frequency meter, unknown signals are compared to the output of a high frequency oscillator in a best detector circuit. The resultant beat notes are amplified and applied to the multi-purpose meter and to the internal speaker. For this mode of operation, the meter operates as a low-frequency beat indicator.

3-3. The high frequency oscillator is controlled by various frequencies, derived from a 1 MHZ crystal oscillator and on interpolating frequency from a low frequency oscillator. In this type of frequency synthesizer, phase-lock loops are used as the control elements and frequency multiplier and divider circuits are used to derive frequencies from the crystal. Figure 3-2 shows a typical controlled frequency and the correlation of dial settings, control frequencies, and final output frequency.

3-4. TIME BASE.

3-5. The first step in the control process is to mix the output of the high frequency oscillator with a stable 132 MHZ time base. This time base is a fixed signal, not affected by dial settings. Since the output frequency is continuously variable from 152 to 164 MHZ, the resultant IF signal is between 20 and 32 MHZ.

3-6. Three multiplier circuits convert the 1 MHZ output of the crystal to 132 MHZ. The output of the crystal oscillator is applied to a harmonic generator which produces 1 MHZ spikes, rich in harmonics. A times 11 multiplier stage selects the 11th harmonic which is converted to 66 MHZ in a times 6 multiplier. The 66 MHZ signal is converted to 132 MHZ in a times 2 multiplier stage. The 132 MHZ time base is therefore as accurate as the 1 MHZ crystal frequency.

3-7. 17 TO 28 MHZ HARMONIC OSCILLATOR.

3-8. The second step in the control process is to mix the first IF signal with the output of a 17 to 28 MHZ oscillator. The frequency of the oscillator is selected by the MHZ control and an output frequency of 17 MHZ corresponds to a dial setting of 152 MHZ. Since the oscillator frequency varies from 17 to 28 MHZ in 12 precise 1 MHZ steps, the resultant IF signal is between 3 and 4 MHZ.

3-9. Rough tuning of the oscillator is accomplished by selection of components and fine tuning by a phase-lock loop. The output frequency of the oscillator is compared to a 1 MHZ pulse from the crystal in a phase detector. When the oscillator frequency is an exact multiple of 1

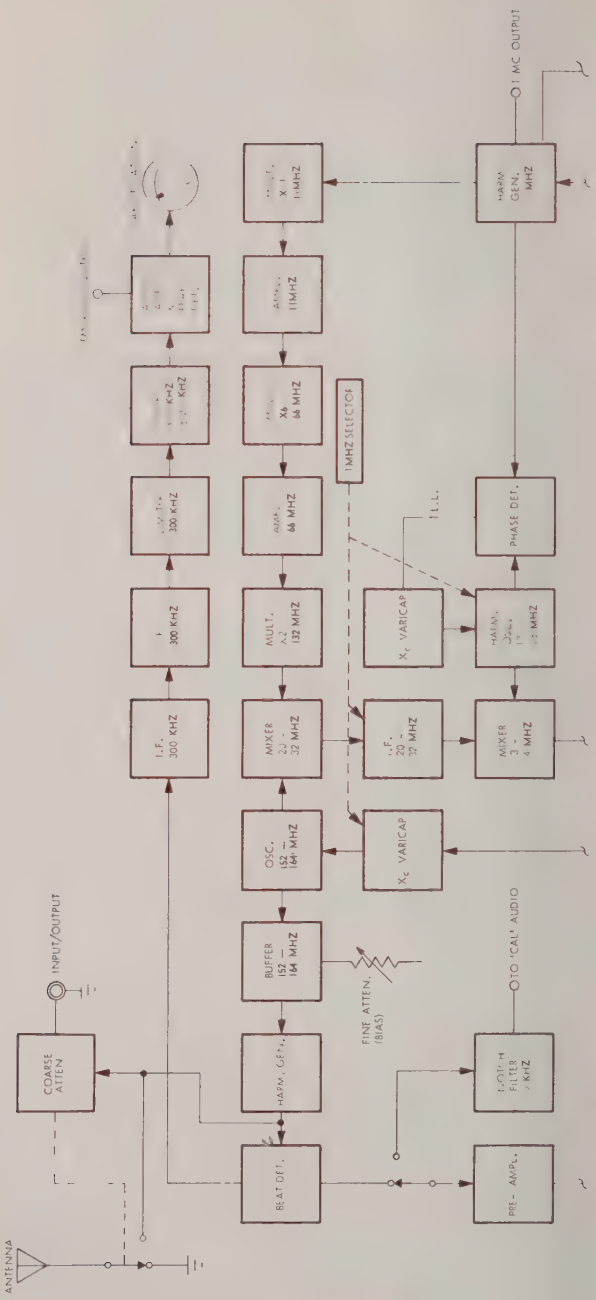
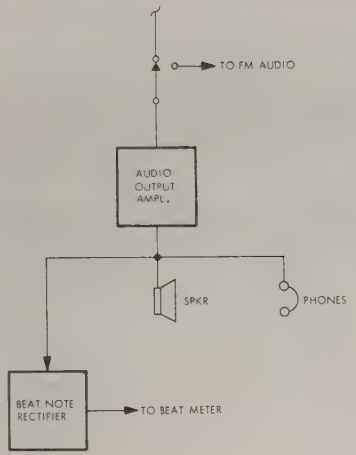
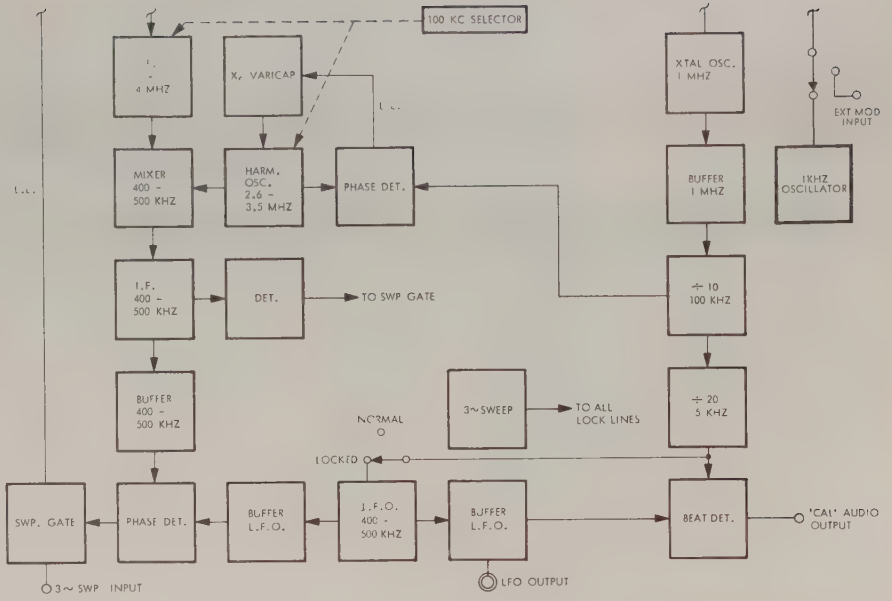


Figure 3-1. Block Diagram


TO FM AUDIO
AUDIO OUTPUT AMPL.
SPKR
PHONES
BEAT NOTE RECTIFIER
TO BEAT METER


100 KC SELECTOR
X, VARICAP
MIXER 400 - 500 KHZ
HARM. OSC. 2.6 - 3.5 MHZ
PHASE DET.
I.F. 400 - 500 KHZ
DET.
TO SWP GATE
BUFFER 400 - 500 KHZ
XTAL OSC. 1 MHZ
BUFFER 1 MHZ
EXT MOD INPUT
1KHZ OSCILLATOR
÷ 10 100 KHZ
÷ 20 5 KHZ
3~SWEEP
TO ALL LOCK LINES
NORMAL
LOCKED
SWP. GATE
PHASE DET.
BUFFER L.F.O.
L.F.O. 400 - 500 KHZ
BUFFER L.F.O.
BEAT DET.
'CAL' AUDIO OUTPUT
3~ SWP INPUT
LFO OUTPUT

MHZ, the phase detector produces a steady dc voltage. Any frequency drift is sensed as phase difference and produces a change in the dc voltage output. The dc voltage output of the phase detector is applied to a voltage sensitive capacitive element in the oscillator tank circuit. Any drift in oscillator frequency results in an automatic retuning of the circuit and thus the oscillator is locked to an exact multiple of the crystal frequency.

3-10. 2.6 TO 3.5 MHZ HARMONIC OSCILLATOR.

3-11. The third step in the control process is to mix the second IF signal with the output of a 2.6 to 3.5 MHZ oscillator. The frequency of the oscillator is selected by the 100 KHZ control and on an output frequency of 2.7 MHZ corresponds to a dial setting of 100 KHZ. Since the oscillator frequency varies from 2.6 to 3.5 MHZ in ten precise 100 KHZ steps, the resultant IF signal is between 400 and 500 KHZ.

3-12. As with the 17 to 28 MHZ oscillator, rough tuning is accomplished by selection of components and fine tuning by a phase-lock loop. 100 KHZ reference pulses are used in the phase-lock loop instead of 1 MHZ pulses. The 100 KHZ pulses are derived from the crystal through a 10 to 1 divider circuit.

3-13. LOW FREQUENCY OSCILLATOR.

3-14. The fourth and final step in the frequency control process is to compare the third IF signal to the interpolating frequency. The 400 to 500 KHZ interpolating frequency is produced by an extremely stable low frequency oscillator equipped with precisely calibrated dials. The output frequency of the oscillator is equal to 400 KHZ plus the setting of the last two frequency dials.

3-15. The two signals are compared in a phase detector which produces a steady dc voltage when the two signals are identical. This dc voltage is applied to a capacitive element in the high frequency oscillator and operates as the final lock voltage.

3-16. For each frequency in the 12 MHZ range, there is a precise dc voltage required to maintain the locked condition. The voltage varies from approximately 3.3 vdc (152 MHZ) to 5.5 vdc (164 MHZ). To assist the system in locating locks, a dc voltage which will produce approximately the required output frequency is applied to the capacitive element of the high frequency oscillator. This voltage is provided by a voltage divider network and selected by the MHZ controls.

3-17. To further assist the system in locating and maintaining a locked frequency, a three HZ sweep voltage is applied to the lock lines. This sweep voltage varies the frequency of the oscillators over a wide range until the lock is achieved. Once lock is achieved, the varying voltage output of the sweep generator is effectively cancelled.

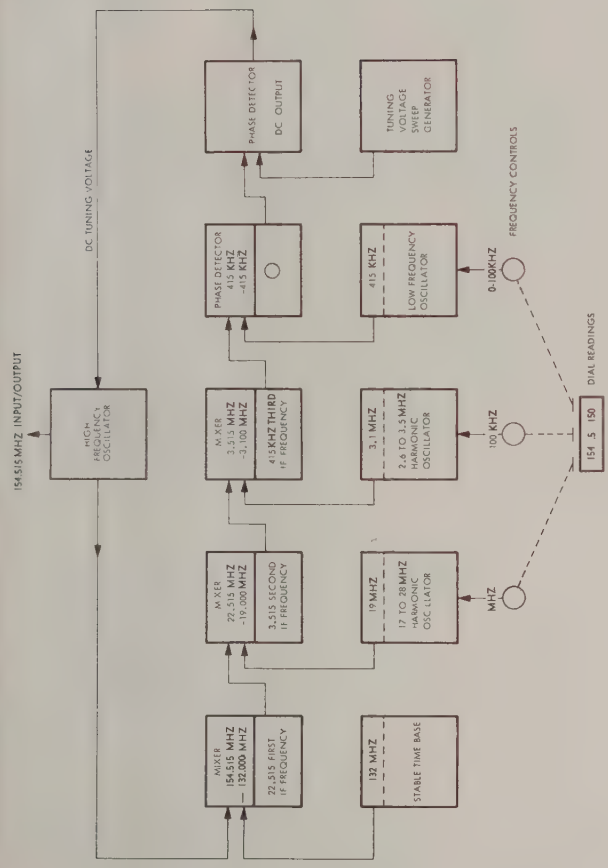


Figure 3-2. Typical Frequency Synthesis

3-18. LFO CALIBRATION.

3-19. The 0-100 KHZ dials may be calibrated against the crystal at each 5 KHZ increment. A 5 KHZ comparison signal is derived from the crystal through two divider circuits: the 10 to 1 divider which produces the 100 KHZ pulses and a 20 to 1 divider circuit produces the 5 KHZ pulses. The output frequency of the low frequency oscillator is compared to harmonics of the 5 KHZ signal in a beat detector.

3-20. SIGNAL GENERATOR OPERATION.

3-21. When the Model FM-9 is used as a signal generator, the output of the high frequency oscillator is applied to the INPUT/OUTPUT jack through an attenuator. As in the frequency meter operation, the output of the high frequency oscillator is a controlled frequency.

3-22. OUTPUT CONTROLS.

3-23. Two controls set the output level of the instrument. A coarse attenuator (RF OUTPUT) consists of a variable T pad which applies up to an 80 db attenuation to the output in 20 db steps. The 20 db steps are marked in equivalent output voltage. A fine attenuator (% RF OUTPUT) consists of a bias potentiometer for the high frequency buffer amplifier. By controlling the bias, the potentiometer controls the output level of the stage. The control is marked in percent and provides control between the steps of the coarse attenuator.

3-24. FM MODULATION.

3-25. The output signal may be modulated by application of the 1 KHZ oscillator output or an external modulating signal. The external signal is applied to the 1 MHZ harmonic oscillator and through the multiplier chain to the time base. Thus the frequency deviation of the input modulating signal is multiplied by 132 in the instrument. Changes in the 132 MHZ time base are detected by the phase lock system, resulting in a change in the output frequency of the high frequency oscillator.

3-26. DEVIATION METER OPERATION. (See figure 3-3.)

3-27. When the Model FM-9 is used as a deviation meter, the system functions essentially as a superheterodyne FM receiver. The discriminator has an IF frequency of 300 KHZ and an output voltage which is directly related to frequency deviation. The output of the discriminator is applied (1) directly to a set of rear panel jacks, (2) through the detector driver and audio amplifier to the speaker, and (3) through the detector driver and either the upper or lower sideband detector to the meter.

3-28. The high frequency oscillator functions as the local oscillator and is controlled in the same manner as for fre-

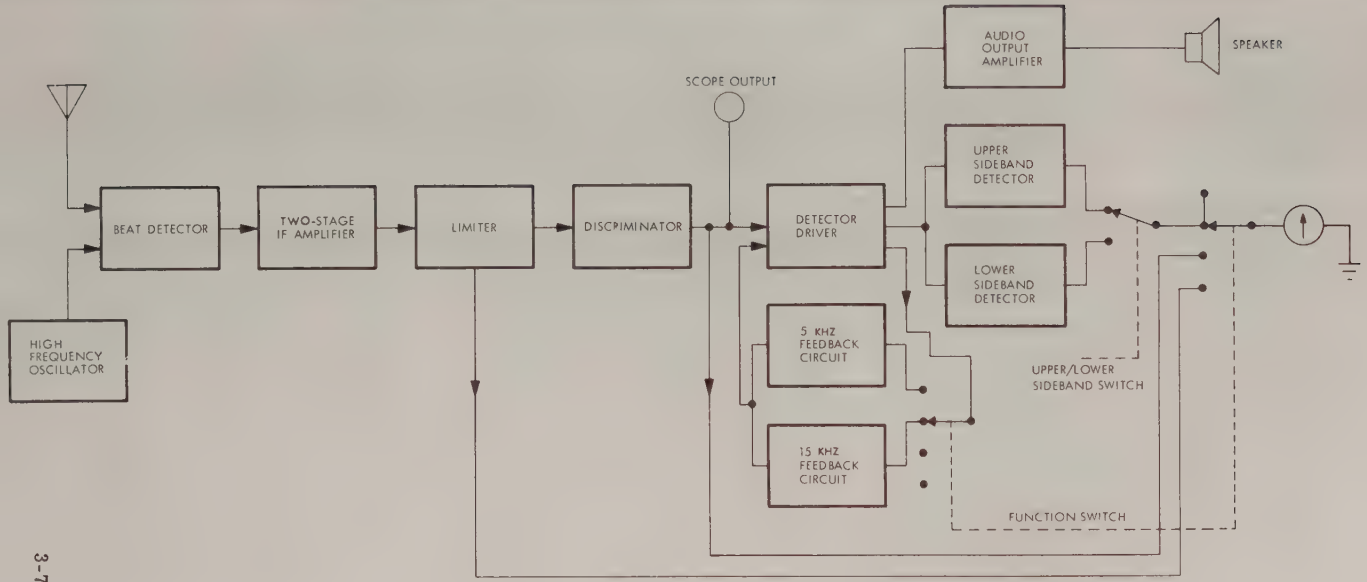


Figure 3-3. Deviation Meter Block Diagram

quency meter operation. When the high frequency oscillator is properly adjusted, the incoming signal and the high frequency oscillator signal are mixed in the beat detector and produce an IF signal of 300 KHZ. When the FUNCTION switch is turned to the FREQ SET position, the frequency adjustment may be checked. When the IF signal is set exactly to the 300 KHZ center frequency, the two sides of the discriminator produce equal and cancelling voltages. The meter then measures only a bias voltage.

3-29. Amplitude variations in the input signal could cause erroneous indications. To eliminate this source of error the signal is amplified by two IF stages and then applied to the limiter. The limiter provides an output signal with an exact amplitude regardless of amplitude variations in the input signal. However, for the limiter to operate properly, a minimum input signal is required. The level of the input signal may be checked by turning the FUNCTION switch to the LIM CUR position. For this check, a special output of the limiter is applied directly to the meter. With sufficient input signal, the meter will deflect to a red line indication.

3-30. The detector driver, detector, and meter function as a peak reading voltmeter circuit. The output of the driver charges a capacitor to the peak voltages which are equivalent to peak frequency deviations. The capacitor discharges through a large resistor and the meter movement. The circuit is calibrated by setting the amount of feedback used in the detector driver circuit. One feedback circuit calibrates the meter for a full scale reading of 5 KHZ and a second circuit calibrates the meter for the 0 to 15 KHZ range.

3-31. POWER SUPPLY. (See figure 3-4.)

3-32. AC POWER OPERATION. When the AC/DC switch is turned to the AC position, 115 vac input power is converted to approximately 15 vdc power in a rectifier circuit and regulated to 9 vdc in a dc regulator circuit. The unregulated 15 vdc power is applied directly to the crystal oven circuit.

3-33. DC POWER OPERATION. When the AC/DC switch is turned to the DC position, 11 to 15 vdc input power is applied through a filter and circuit breaker to the DC regulator and to the oven heater circuit.

3-34. BATTERY CHARGE OPERATION. When the BATTERY CHARGE switch is turned to the CHARGE position, the DC regulator is converted to a 13.5 vdc charge circuit and delivers power to the battery. For this operation, the meter is converted to a dc voltmeter.

3-35. CRYSTAL OVEN. An electrical element provides heat for the oven. A mercury thermostat controls temperature through a transistor switching circuit. The oven indicator lights when power is applied to the heating element.

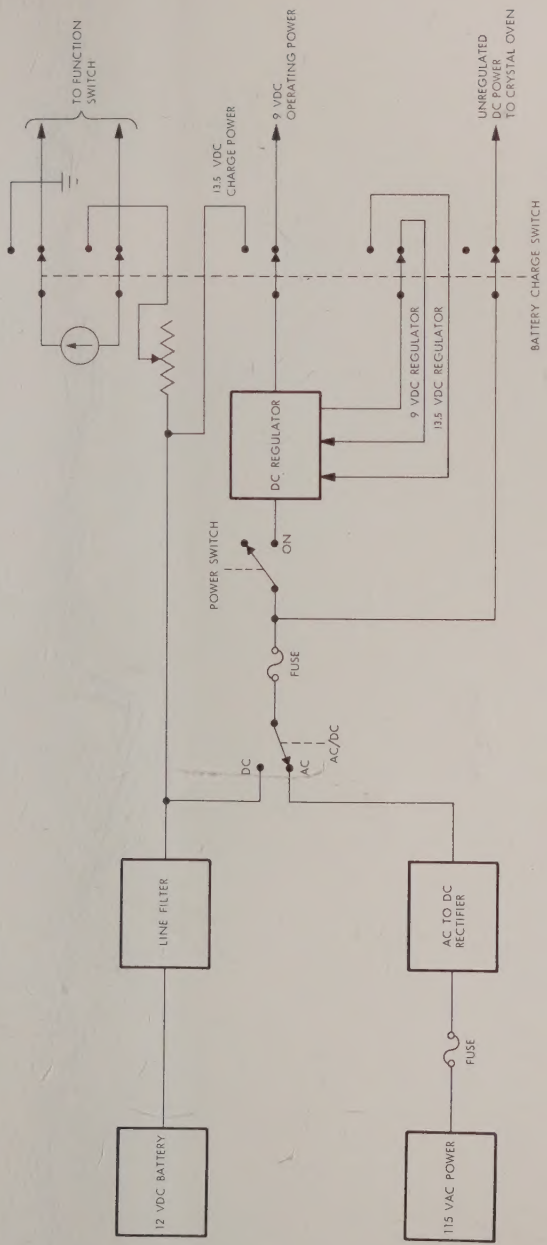


Figure 3-4. Power Supply Simplified Diagram